Claims

1. A method for encoding data for transmission over a telecommunications network comprising embedding a control data block within a plurality of real data blocks; modulating or transforming real data in the real data blocks with one or more sub-carrier signals; and modulating or transforming data in the control data block with every sub-carrier that is used to modulate the real data.

2. A method as claimed in claim 1, wherein each of the control and real data blocks has *m* entries, where *m* is an integer of one or more, and *m* sub-carrier transmission channels are provided, and each control data entry and each real data entry are modulated with the corresponding sub-carrier.

3. A method as claimed in claim 1 or claim 2 further comprising convoluting real data in the real data blocks with at least some of the control data in the control data blocks.

4. A method as claimed in claim 3, wherein the step of convoluting involves phase angle convoluting each entry in each real data block with a phase angle of the corresponding entry in the control block.

5. A method as claimed in claim 4, wherein the step of phase angle convoluting involves adding the phase angle of each entry of the control data block to the phase angle of the corresponding entry of each real data block.

6. A method as claimed in claim 5, wherein the

convoluted encoded data blocks can be represented by: $X_{nm}=A_{nmo}exp(j(\phi_{nmo}+\phi_{kmo})$, where X_{nmo} is the original encoded quadrature signal in data block *n* for sub-carrier *m*; ϕ_{nm0} is the original phase angle for data block *n* and sub-carrier *m*; and ϕ_{km0} is the original phase angle for the control data block and sub-carrier *m*.

7. A method as claimed in any of the preceding claims, wherein each phase angle for the control data in the control data block is randomly assigned.

8. A method as claimed in any of claims 1 to 6, wherein each entry of the control data block has a phase angle that is a function of the phase angles of the corresponding entries of the real data blocks.

9. A method as claimed in claim 8, wherein the phase angle of each entry of the control data block is the sum of the phase angles of the corresponding entries of real data blocks.

10. A method as claimed in claim 9, comprising phase angle convoluting each entry of each data block with the phase angles of the corresponding entries of the other real data blocks.

11. A method as claimed in claim 10, wherein the step of convoluting comprises subtracting from the phase angle of each real data entry all of the phase angles of all of the corresponding entries of all of the other real data blocks.

12. A method as claimed in claim 11, when dependent directly or indirectly on claim 9, wherein the encoding

of an N block data transmission can be represented as follows:

$$X_{1m0} = I^c_{1m0} + jQ^c_{1m0} = A_{1m0}\exp\left(j\left(\alpha_{1m}\phi_{1m0} - \alpha_{2m}\phi_{2m0} - \alpha_{3m}\phi_{3m0} - \quad \dots \quad - \alpha_{Nm}\phi_{Nm0}\right)\right)$$

$$X_{2m0} = I^c_{2m0} + jQ^c_{2m0} = A_{2m0}\exp\left(j\left(\alpha_{2m}\phi_{2m0} - \alpha_{1m}\phi_{1m0} - \alpha_{3m}\phi_{3m0} - \quad \dots \quad - \alpha_{Nm}\phi_{Nm0}\right)\right)$$

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$$X_{km0} = I^c_{km0} + jQ^c_{km0} = A_{km0}\exp\left(-j\left(\alpha_{1m}\phi_{1m0} + \alpha_{2m}\phi_{2m0} + \alpha_{3m}\phi_{3m0} + \quad \dots \quad + \alpha_{Nm}\phi_{Nm0}\right)\right)$$

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$$X_{Nm0} = I^c_{Nm0} + jQ^c_{Nm0} = A_{Nm0}\exp\left(j\left(\alpha_{Nm}\phi_{Nm0} - \alpha_{1m}\phi_{1m0} - \alpha_{2m}\phi_{2m0} - \quad \dots \quad - \alpha_{(N-1)m}\phi_{(N-1)m0}\right)\right)$$

where the terms α_{nm} $(n = 1, 2 \dots N)$ are constants associated with the convolution of each encoded phase angle on the sub-carrier.

13. A method as claimed in any of the preceding claims, wherein the step of modulating comprises frequency modulating the signal.

14. A method as claimed in any of the preceding claims comprising receiving data for transmission to a receiver, dividing the data into N-1 data blocks and embedding a the control data block into the N-1 data blocks to provide a N block data transmission.

15. A method as claimed in any of the preceding claims wherein the control data block is embedded substantially in the middle of the real data blocks.

16. A method as claimed in any of the preceding claims wherein a plurality of control data blocks are embedded within the real data blocks.

17. A method for decoding data received over a telecommunications network, the method comprising: receiving a modulated control block embedded in a plurality of modulated data blocks, identifying the received control data block, and estimating the data in each of the original data blocks using each entry of the received control data block and the corresponding entries of the received data blocks.

18. A method as claimed in claim 17 wherein the step of estimating involves dividing each entry of the received real data blocks with the corresponding entry of the control data block.

19. A method as claimed in claim 17 or claim 18, wherein the original data blocks were phase convoluted using the phase angles of the original control data block and the step of estimating uses the following algorithms:

$$\hat{I}_{nm} = A_{km0}\frac{(I_{nm}I_{km} + Q_{nm}Q_{km})}{(I_{km}{}^2 + Q_{km}{}^2)} = \hat{A}_{nm}\cos\hat{\phi}_{nm} \qquad n = 1, 2, \ldots N\ (n \neq k)$$

$$\hat{Q}_{nm} = A_{km0}\frac{(I_{km}Q_{nm} - I_{nm}Q_{km})}{(I_{km}{}^2 + Q_{km}{}^2)} = \hat{A}_{nm}\sin\hat{\phi}_{nm} \qquad n = 1, 2, \ldots N\ (n \neq k)$$

where A_{km0} is a known control value; I_{nm} and Q_{nm} are the demodulated components of the m sub-carriers of the N data blocks in the presence of attenuation and/or channel distortion; and I_{km} and Q_{km} are the demodulated components of the m sub-carriers of the control data block in the presence of attenuation and/or channel distortion in the presence of attenuation and channel distortion.

20. A method as claimed in any of claims 17 to 19

comprising receiving a serial stream of data and re-constructing from this the modulated control block and the plurality of modulated data blocks.

21. An encoder for encoding data for transmission over a telecommunications network, the encoder being configured to: embed a control data block within a plurality of real data blocks; modulate or transform real data in the real data blocks with one or more sub-carrier signals; and modulate or transform data in the control data block with every sub-carrier that is used to modulate the real data.

22. An encoder as claimed in claim 21, wherein each of the control and real data blocks has *m* entries, where *m* is an integer of one or more, and *m* sub-carrier transmission channels are provided, and each control data entry *n*, where *n* = *1* … *m*, and each real data entry *n* are modulated with the corresponding sub-carrier *n*.

23. An encoder as claimed in claim 21 or claim 22 further configured to convolute real data in the real data blocks with at least some of the control data in the control data blocks.

24. An encoder as claimed in claim 23 configured to phase angle convolute each entry in each real data block with a phase angle of the corresponding entry in the control block.

25. An encoder as claimed in claim 24 configured to add the phase angle of each entry of the control data block to the phase angle of the corresponding entry of each real data block.

26. An encoder method as claimed in claim 25, wherein the convoluted encoded data blocks can be represented by: $X_{nm}=A_{nmo}exp(j(\phi_{nmo}+\phi_{kmo})$, where X_{nmo} is the original encoded quadrature signal in data block n for sub-carrier m; ϕ_{nm0} is the original phase angle for data block n and sub-carrier m; and ϕ_{km0} is the original phase angle for the control data block and sub-carrier m.

27. An encoder as claimed in any of claims 21 to 26, wherein each phase angle for the control data in the control data block is randomly assigned.

28. An encoder as claimed in any of claims 21 to 27, configured to assign to each entry of the control data block a phase angle that is a function of the phase angles of the corresponding entries of the real data blocks.

29. An encoder as claimed in claim 28, wherein the phase angle of each entry of the control data block is the sum of the phase angles of the corresponding entries of real data blocks.

30. An encoder as claimed in claim 29 configured to phase angle convolute each entry of each data block with the phase angles of the corresponding entries of the other real data blocks.

31. An encoder as claimed in claim 30 configured to convolute the phase angles by subtracting from the phase angle of each real data entry all of the phase angles of all of the corresponding entries of all of the other real data blocks.

32. An encoder as claimed in any of claims 21 to 31 configured to receive data for transmission, divide the data into *N-1* data blocks and embed the control data block into the *N-1* data blocks to provide a N block data transmission.

33. An encoder method as claimed in any of claims 21 to 32 configured to embed the control data block substantially in the middle of the real data blocks.

34. An encoder as claimed in any of claims 21 to 33 configured to embed a plurality of control data blocks within the real data blocks.

35. A decoder for decoding data received over a telecommunications network configured to receive a modulated control block embedded in a plurality of modulated data blocks; identify the received control data block, and estimate the data in each of the original data blocks using each entry of the received control data block and the corresponding entries of the received data blocks.

36. A decoder as claimed in claim 35 configured to estimate the data in each original block by dividing each entry of the received real data blocks with the corresponding entry of the control data block.

37. A decoder as claimed in claim 35 or claim 36, wherein the original data blocks were phase convoluted using the phase angles of the original control data block.

38. A decoder as claimed in claim 37 operable to

estimate the data using the following algorithms:

$$\hat{I}_{nm} = A_{km0}\frac{(I_{nm}I_{km}+Q_{nm}Q_{km})}{(I_{km}{}^2+Q_{km}{}^2)} = \hat{A}_{nm}\cos\hat{\phi}_{nm} \qquad n=1,2,\dots N\ (n\neq k)$$

$$\hat{Q}_{nm} = A_{km0}\frac{(I_{km}Q_{nm}-I_{nm}Q_{km})}{(I_{km}{}^2+Q_{km}{}^2)} = \hat{A}_{nm}\sin\hat{\phi}_{nm} \qquad n=1,2,\dots N\ (n\neq k)$$

where A_{km0} is a known control value; I_{nm} and Q_{nm} are the demodulated components of the m sub-carriers of the N data blocks in the presence of attenuation and/or channel distortion; and I_{km} and Q_{km} are the demodulated components of the m sub-carriers of the control data block in the presence of attenuation and/or channel distortion in the presence of attenuation and channel distortion.

39. A decoder as claimed in any of claims 35 to 38 configured to receive a serial stream of data and re-construct from this the modulated control block and the plurality of modulated data blocks.

40. A system for encoding data for transmission over a telecommunications network comprising means for embedding a control data block within a plurality of real data blocks; means for modulating or transforming real data in the real data blocks with one or more sub-carrier signals; and means for modulating or transforming data in the control data block with every sub-carrier that is used to modulate the real data.

41. A system as claimed in claim 40, wherein each of the control and real data blocks has m entries, where m is an integer of one or more, and m sub-carrier transmission channels are provided, and each control data entry and each real data entry are modulated with the corresponding

sub-carrier.

42. A system as claimed in claim 40 or claim 41 further comprising means for convoluting real data in the real data blocks with at least some of the control data in the control data blocks, preferably wherein the means for convoluting are operable to phase angle convolute each entry in each real data block with a phase angle of the corresponding entry in the control block.

43. A system as claimed in claim 42, wherein the means for phase angle convoluting are operable to add the phase angle of each entry of the control data block to the phase angle of the corresponding entry of each real data block.

44. A system as claimed in claim 43, wherein the convoluted encoded data blocks are represented by: $X_{nm}=A_{nmo}exp(j(\phi_{nmo}+\phi_{kmo})$, where X_{nmo} is the original encoded quadrature signal in data block n for sub-carrier m; ϕ_{nm0} is the original phase angle for data block n and sub-carrier m; and ϕ_{km0} is the original phase angle for the control data block and sub-carrier m.

45. A system as claimed in any claims 40 to 44 comprising means for randomly assigning each phase angle for the control data in the control data block.

46. A system as claimed in any of claims 40 to 45, wherein each entry of the control data block has a phase angle that is a function of the phase angles of the corresponding entries of the real data blocks.

47. A system as claimed in claim 46, wherein the means for

convoluting are operable to sum of the phase angles of corresponding entries of the real data blocks and assign that sum as the phase angle for the corresponding control data.

48. A system as claimed in claim 46 or claim 47, comprising means for phase angle convoluting each entry of each data block with the phase angles of the corresponding entries of the other real data blocks.

49. A system as claimed in claim 48, wherein the means for convoluting the real data are operable to subtract from the phase angle of each real data entry all of the phase angles of all of the corresponding entries of all of the other real data blocks.

50. A system as claimed in claim 49 wherein the encoding of an *N* block data transmission can be represented as follows:

$$X_{1m0} = I^c_{1m0} + jQ^c_{1m0} = A_{1m0}\exp\left(j\left(\alpha_{1m}\phi_{1m0} - \alpha_{2m}\phi_{2m0} - \alpha_{3m}\phi_{3m0} - \quad \ldots \quad - \alpha_{Nm}\phi_{Nm0}\right)\right)$$

$$X_{2m0} = I^c_{2m0} + jQ^c_{2m0} = A_{2m0}\exp\left(j\left(\alpha_{2m}\phi_{2m0} - \alpha_{1m}\phi_{1m0} - \alpha_{3m}\phi_{3m0} - \quad \ldots \quad - \alpha_{Nm}\phi_{Nm0}\right)\right)$$

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$$X_{km0} = I^c_{km0} + jQ^c_{km0} = A_{km0}\exp\left(-j\left(\alpha_{1m}\phi_{1m0} + \alpha_{2m}\phi_{2m0} + \alpha_{3m}\phi_{3m0} + \quad \ldots \quad + \alpha_{Nm}\phi_{Nm0}\right)\right)$$

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$$X_{Nm0} = I^c_{Nm0} + jQ^c_{Nm0} = A_{Nm0}\exp\left(j\left(\alpha_{Nm}\phi_{Nm0} - \alpha_{1m}\phi_{1m0} - \alpha_{2m}\phi_{2m0} - \quad \ldots \quad - \alpha_{(N-1)m}\phi_{(N-1)m0}\right)\right)$$

where the terms α_{nm} *(n = 1, 2 ...N)* are constants associated with the convolution of each encoded phase angle on the sub-carrier.

51. A system as claimed in any of claims 40 to 49 comprising means for receiving data for transmission; means for dividing the data into *N-1* data blocks and means for embedding the control data block into the *N-1* data blocks to provide a *N* block data transmission.

52. A system as claimed in any of claims 40 to 51 wherein the control data block is embedded substantially in the middle of the real data blocks.

53. A system as claimed in any of claims 40 to 52 wherein the means for embedding the control data block are operable to embed a plurality of such control data blocks within the real data blocks.

54. A system for decoding data received over a telecommunications network, the system comprising: means for receiving a modulated control block embedded in a plurality of modulated data blocks; means for identifying the received control data block, and means for estimating the data in each of the original data blocks using each entry of the received control data block and the corresponding entries of the received data blocks.

55. A system as claimed in claim 54 wherein the means for estimating are operable to divide each entry of the received real data blocks with the corresponding entry of the control data block.

56. A system as claimed in claim 54 or claim 55, wherein the original data blocks were phase convoluted using the phase angles of the original control data block.

57. A system as claimed in claim 56 wherein the means for estimating are operable to use the following algorithms:

$$\hat{I}_{nm} = A_{km0}\frac{(I_{nm}I_{km} + Q_{nm}Q_{km})}{(I_{km}^{2} + Q_{km}^{2})} = \hat{A}_{nm}\cos\hat{\phi}_{nm} \qquad n = 1, 2, \ldots N\ (n \neq k)$$

$$\hat{Q}_{nm} = A_{km0}\frac{(I_{km}Q_{nm} - I_{nm}Q_{km})}{(I_{km}^{2} + Q_{km}^{2})} = \hat{A}_{nm}\sin\hat{\phi}_{nm} \qquad n = 1, 2, \ldots N\ (n \neq k)$$

where A_{km0} is a known control value; I_{nm} and Q_{nm} are the demodulated components of the m sub-carriers of the N data blocks in the presence of attenuation and/or channel distortion; and I_{km} and Q_{km} are the demodulated components of the m sub-carriers of the control data block in the presence of attenuation and/or channel distortion in the presence of attenuation and channel distortion.

58. A system as claimed in any of claims 54 to 57 comprising means for receiving a serial stream of data and means for re-constructing from this the modulated control block and the plurality of modulated data blocks.

59. A computer program, preferably on a data carrier or a computer readable medium, having code or instructions for encoding data for transmission over a telecommunications network, the program comprising embedding a control data block within a plurality of real data blocks; modulating or transforming real data in the real data blocks with one or more sub-carrier signals; and modulating or transforming data in the control data block with every sub-carrier that is used to modulate the real data.

60. A computer program as claimed in claim 59, wherein each of the control and real data blocks has m entries,

where m is an integer of one or more, and m sub-carrier transmission channels are provided, and each control data entry and each real data entry are modulated with the corresponding sub-carrier.

61. A computer program as claimed in claim2 59 and 60 further comprising code or instructions for convoluting real data in the real data blocks with at least some of the control data in the control data blocks.

62. A device that includes an encoder and/or decoder as claimed in any one of claims 21 to 39.

63. A device as claimed in claim 62, the device being any telecommunications device, such as a personal mobile communications device or mobile/radio telephone or a computer with telecommunications capabilities or a digital broadcast radio or a digital television or set top box or any wireless networked device.

64. A device that includes a system as claimed in any one of claims 40 to 58.

65. A device as claimed in claim 64, the device being any telecommunications device, such as a personal mobile communications device or mobile/radio telephone or a computer with telecommunications capabilities or a digital broadcast radio or a digital television or set top box or any wireless networked device.

66. A telecommunications signal that is the product of the method of any one of claims 1 to 17.

67. A telecommunications signal that is the product of the

encoder of any one of claims 21 to 34 or the encoding system of any one of claims 40 to 53.